Exhibit A to

Second Response to Office Action

CS152
Computer Architecture and Engineering

Lecture 5: Cost and Design

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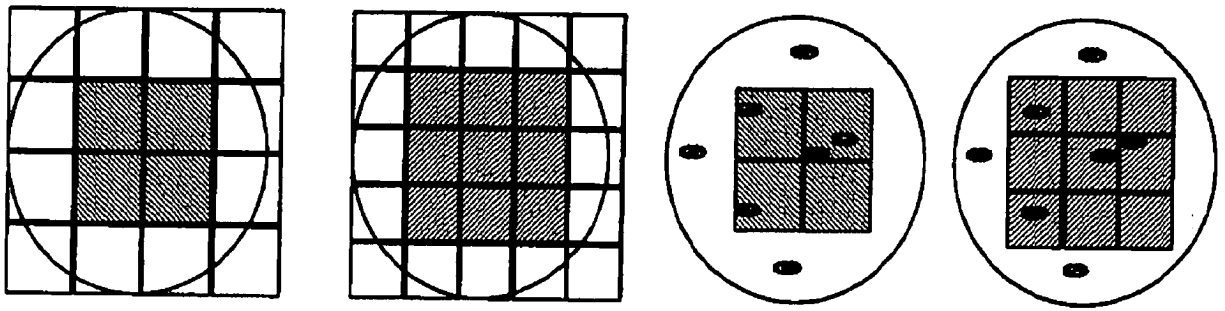
lecture slides: http://www-inst.eecs.berkeley.edu/~cs152/

Integrated Circuit Costs

$$\text{Die cost} = \frac{\text{Wafer cost}}{\text{Dies per Wafer} * \text{Die yield}}$$

$$\text{Dies per wafer} \sim \frac{\text{eff Wafer Area}}{\text{Die Area}}$$



$$\text{Die Yield} = \frac{\text{Wafer yield}}{\left\{ 1 + \frac{\text{Defects\_per\_unit\_area} * \text{Die\_Area}}{?} \right\}^{?}}$$

Die Cost is goes roughly with the cube of the area.

Die Yield

wafer diameter	Raw Dices Per Wafer die area (mm^2) 100	144	196	256	324	400
6"/15cm	139	90	62	44	32	23
8"/20cm	265	177	124	90	68	52
10"/25cm	431	290	206	153	116	90
die yield	23%	19%	16%	12%	11%	10%

typical CMOS process: ? =2, wafer yield=90%, defect density=2/cm2, 4 test sites/wafer

Good Dices Per Wafer (Before Testing!)						
6"/15cm	31	16	9	5	3	2
8"/20cm	59	32	19	11	7	5
10"/25cm	96	53	32	20	13	9

typical cost of an 8", 4 metal layers, 0.5um CMOS wafer: ~$2000

Real World Examples

Chip	Metal layers	Line width	Wafer cost	Defect /cm^2	Area mm^2	Dies/ wafer	Yield	Die Cost
386DX	2	0.90	$900	1.0	43	360	71%	$4
486DX2	3	0.80	$1200	1.0	81	181	54%	$12
PowerPC 601	4	0.80	$1700	1.3	121	115	28%	$53
HP PA 7100	3	0.80	$1300	1.0	196	66	27%	$73
DEC Alpha	3	0.70	$1500	1.2	234	53	19%	$149
SuperSPARC	3	0.70	$1700	1.6	256	48	13%	$272
Pentium	3	0.80	$1500	1.5	296	40	9%	$417

From "Estimating IC Manufacturing Costs," by Linley Gwennap, *Microprocessor Report*, August 2, 1993, p. 15

Other Costs

$$\text{IC cost} = \frac{\text{Die cost} + \text{Testing cost} + \text{Packaging cost}}{\text{Final test yield}}$$

Packaging Cost: depends on pins, heat dissipation

Chip	*Die cost*	*Package pins*	*Package type*	*Package cost*	*Test & Assembly*	*Total*
386DX	$4	132	QFP	$1	$4	$9
486DX2	$12	168	PGA	$11	$12	$35
PowerPC 601	$53	304	QFP	$3	$21	$77
HP PA 7100	$73	504	PGA	$35	$16	$124
DEC Alpha	$149	431	PGA	$30	$23	$202
SuperSPARC	$272	293	PGA	$20	$34	$326
Pentium	$417	273	PGA	$19	$37	$473